Abstract

Construction industries in India are predominantly dominated by reinforced concrete structures, mainly because of their relatively long experiences and cheaper unskilled workforce. However, in the last few decades, steel constructions in India, using cold-formed steel tubular/hollow sections, have become increasingly popular, as can be witnessed from many public and industrial structures. Among the various constructional steels available in India, the YSt-310 cold-formed steel tubular sections, conforming to IS 4923 (1997), is one of the most commonly preferred steel material for structural use. However, to the best of authors' knowledge, detailed and reliable material data including member test, for this particular steel are very limited or do not exist readily in the public domain. Moreover, the existing design equations, which were predominantly developed based on hot-rolled steels, relied on the elastic and perfectly plastic stress-strain material model, essentially ignoring the beneficial effect of strength enhancement from cold-forming. Consequently, the design practice results in overly conservative predictions, thus increasing the cost of construction. The primary objective of this study is then to setup a reliable material characteristics database for YSt-310 steel at various temperature levels, as well as to investigate the structural performance of both unperforated and perforated stub columns.

As a part of the study, material characteristics of YSt-310 cold-formed steel tubular sections have been studied at ambient temperature, elevated temperature and post-fire conditions. In the ambient temperature study, chemical compositions, metallographic examinations and mechanical properties have been estimated using standard test procedures. The investigations on the mechanical properties have further been extended to elevated temperatures and post-fire conditions, and reduction factors of key material parameters have been estimated. Relationships between post-fire mechanical properties and microhardness values have also been established. Design reduction factors have been proposed for both elevated temperature and post-fire conditions, using the present and existing test results.

Structural performance of YSt-310 cold-formed steel tubular stub columns has been studied through experimental and numerical investigations. The extent of corner strength enhancement due to cold-forming has been studied using microhardness test. Additionally, geometric imperfections of stub columns have been measured by employing a non-contact 3D laser scanner. A total of 12 stub column have been tested, and the results been utilised to develop finite element models for parametric study, taking into account the geometric and material non-

linearity. Using test and FE column capacities, the feasibility of current design guidelines for cold-formed tubular stub columns have been assessed and found to provide conservative predictions. An improved, modified design approach based on direct strength method (DSM) has been proposed which takes into account of strain-hardening behaviour of cold-formed steel tubular stub columns, observed at low slenderness ranges.

The study on the structural performance of YSt-310 cold-formed steel tubular stub columns has further been expanded by incorporating two opposite central circular perforations at mid-height of the column. The influence of perforations on the column capacities has been studied through experimental and validated FE models, covering a wide range of perforation sizes and cross-section slenderness. Additionally, imperfection amplitude models based on Dawson and Walker model have been proposed for both unperforated and perforated cold-formed steel stub columns using imperfection measurement results. The applicability of existing design equations for perforated columns has then been assessed using the columns capacities generated from test and FE results. A set of modified equations for the design of perforated cold-formed steel stub columns, for different perforation sizes, has been proposed based on DSM approach.